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Site Rehabilitation Under Planted Redcedar and Pine

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EASTERN REDCEDAR (*Juniperus virginiana* L.) enjoys a reputation for production of litter relatively rich in nitrogen and calcium, and for development of soils that have higher organic matter content, higher water transmission rates, and higher pH than soils under pine or herbaceous cover (*2, 4*). Loblolly (*Pinus taeda* L.) and shortleaf (*P. echinata* Mill.) pines are better known for their ability to arrest soil movement on eroded sites through the rapid buildup of litter than for any capacity to modify soil properties (*1*). It has been found that pine litter accumulation to a depth of 1.3 cm will largely halt soil movement and will control surface runoff (*5*).

The study described here compares long-term changes in the physical and chemical properties of soil and litter on eroded old fields planted to pure stands of redcedar, loblolly pine, shortleaf pine, and mixtures of redcedar with loblolly and redcedar with shortleaf. The objective was to determine which species or species combination rehabilitated the site most rapidly. An increase in water transmission rate through the soil was considered direct evidence of site rehabilitation. Increases in litter depth, soil organic matter, large pore space, and nutrient content of soil and litter were regarded as indirect evidence of rehabilitation.

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Methods

Five fields on the Holly Springs National Forest in northern Mississippi were selected for study. The soil on them was thin, loessial, and classified as Lexington. The fields, clustered within 150 m of each other, had been abandoned for ten or more years and were vegetated with a scattering of blackjack oaks (*Quercus marilandica* Muenchh.), shortleaf pines, persimmon (*Diospyros virginiana* L.), sumac (*Rhus* spp.), and native grasses. The woody plants were cut down and removed prior to the experiment.

One 0.04-ha plot was located on each of the five fields, and one species or combination of species was randomly assigned to each plot. The five planting treatments were: pure redcedar, loblolly, shortleaf pine, redcedar with shortleaf, and redcedar mixed with loblolly pine. One-year-old seedlings were planted in February 1950 at a 1.5 by 1.8 m spacing. On the mixed plots, species were planted alternately within rows to achieve a checkerboard pattern.

Plot slopes ranged from nearly level to gentle. The pure redcedar, pure shortleaf, and redcedar-loblolly plots had slopes of 1 to 2 percent. The pure loblolly and redcedar-shortleaf plots had slopes of 5 to 8 percent.

For sampling purposes, each plot was subdivided into five units and three sampling points were randomly located within each unit. Soil and litter samples were taken in 1951 (one year after planting) and in 1966.

Depth, weight, and nitrogen and calcium contents of litter samples were determined for each plot. Depth was measured to the nearest 0.1 inch and results were converted to millimeters. Oven-dried weight of litter was determined after 48 hours at 70 C; higher temperatures were avoided to prevent loss of nitrogen (*3*). The fifteen samples were composited into three replications for chemical analyses. Litter nitrogen content was determined by the Kjeldahl method and calcium by emission spectrophotometry.

Since previous experience indicated that any major changes would take place in the uppermost soil layer (*2*), only the top 5 cm of mineral soil were sampled for determination of physical and chemical properties. Depth of the A_1 horizon, volume weight, large and total pore space, water transmission rates, contents of nitrogen, exchangeable calcium, and organic matter, and quantity of exchangeable bases were measured.

Depth of the A_1 horizon was measured to the nearest 0.1 inch, and results were converted to millimeters. Volume weight was calculated from undisturbed oven-dried samples of known volume. Large

pore values were derived from undisturbed samples which were placed on a tension table at 60 cm suction. Total pore space was calculated as the difference between saturated and oven-dried weight of the undisturbed samples.

For measurement of water transmission rates, metal rings 17.8 cm in diameter were driven several centimeters into the ground at 15 points on each plot midway between planted trees. Next, a 1,000-cc burette filled with water was set up with the tip touching the soil surface. The soil was protected from erosion by placing a small leaf between the burette tip and the ground. The burette was opened briefly to moisten the soil, then its top was sealed and the stopcock was opened. The time required for 630 cc to flow from the burette was determined with a stop watch. As water soaked into the soil, air entered the burette and permitted additional water to flow. A thin layer of water was maintained on the plots, but no appreciable head of water built up on any but sloping plots.

In both 1951 and 1966, water transmission rates were measured in late winter when the soil profile was well charged and soil moisture content was near field capacity.

Soil nitrogen content was determined by the Kjeldahl method, exchangeable calcium by the weak acid-ammonium fluoride method, and organic matter was determined colorimetrically after digestion with potassium dichromate.

Heights and diameters of trees on all plots were measured in 1966.

Results and Discussion

By 1966, the plot of pure redcedar had been heavily invaded by trees of other species (Table 1). The main reason for invasion was slow crown closure caused by slow growth and heavy deer browsing. Pines grew much faster than redcedar.

As anticipated, the most litter accumulated under pure stands of pine. Litter there was more than twice as deep and three to four times as heavy as that under pure redcedar (Table 2). If 1.3 cm of litter is accepted as a minimum depth for erosion control (*5*), the redcedar, with only 0.6 cm, has failed to protect the site.

On the redcedar plot in 1966, six of the 15 samples taken to determine depth of the A_1 horizon showed evidence of recent soil movement. In the six, the A_1 horizon was buried under 1.3 cm or more of fresh alluvium. Since the redcedar plot is on an upland flat with 1 percent slope, all soil movement had to be from within the plot. These data confirm the need for approximately 1.3 cm of litter for site protection.

Table 1. STAND DEVELOPMENT, 1950-1966

Plot	Species	Trees per ha 1950	Trees per ha 1966	Basal area 1966	Height of dominants	Average dbh
				m^2/ha	*m*	*cm*
Redcedar	Redcedar	3,804	3,013	4.61	6.7	3.8
	Shortleaf	....	840	7.64	9.4	9.4
	Miscellaneous	....	1,037	0.48	......	......
	Total		4,890	12.73		
Shortleaf	Shortleaf	3,804	3,927[1]	30.67	10.7	8.9
	Miscellaneous	....	568	0.76	......	......
	Total		4,495	31.43		
Loblolly	Loblolly	3,804	2,692	30.25	13.1	10.9
	Miscellaneous	....	1,754	1.42	......	......
	Total		4,446	31.67		
Redcedar-shortleaf	Shortleaf	1,902	3,162[1]	19.99	8.8	8.1
	Redcedar	1,902	1,482	1.88	5.5	3.8
	Miscellaneous	....	321	0.18	......	......
	Total		4,965	22.05	......	......
Redcedar-loblolly	Loblolly	1,902	1,704	22.13	12.2	12.4
	Redcedar	1,902	1,013	1.06	5.2	3.6
	Miscellaneous	....	815	0.87	......	......
	Total		3,532	24.06		

[1] Includes shortleaf volunteers.

Water transmission rates increased on three of the five plots over the 15 years (Table 3). Rates remained unchanged under the redcedar-shortleaf mixture, and they decreased on the pure redcedar plot. Transmission is now three to five times faster under the pure pines than under the pure redcedar. The reduction in transmission rate under the redcedar probably is caused by soil movement, which is still occurring on that plot.

Under shortleaf, the litter contained more nitrogen and calcium and the soil contained more organic matter than under loblolly pine. Loblolly, on the other hand, produced more litter than shortleaf, and water transmission was more rapid beneath it (Tables 2 and 3). Thus, of the two pines, loblolly appears to be superior for site protection and rehabilitation.

Table 2. CHANGES IN AMOUNT AND COMPOSITION OF LITTER

Plot	Year	Depth	Litter measurements: Dry weight	N	Ca
		cm	*kg/ha*	*% by weight*	
Redcedar	1951	0.38	2,645	0.75	0.51
	1966	0.64	4,875	0.85	1.06
Shortleaf	1951	0.28	2,295	0.72	0.41
	1966	1.42	14,459	0.90	0.70
Loblolly	1951	0.23	1,484	0.72	0.69
	1966	2.29	19,510	0.75	0.40
Redcedar-shortleaf	1951	0.18	1,173	0.64	0.43
	1966	0.84	9,587	0.94	0.71
Redcedar-loblolly	1951	0.30	3,305	0.69	0.56
	1966	1.65	13,664	0.77	0.31

Under redcedar, the litter contained more calcium and the top 5 cm of soil contained more organic matter than under the pines. More nitrogen and calcium also tended to accumulate in the soil beneath redcedar. However, these favorable increases in soil and litter nutrients were not accompanied by beneficial changes in physical properties.

Mixtures of pine and redcedar appeared to offer no advantages. In no instances were the physical or chemical properties of soil or litter under mixed plantings superior to those under pure pine plantings. In several cases, the mixtures were inferior to pure plantings. Height growths of both pines and redcedar were poorer in mixed than in pure plantings.

Summary

Plantations of three coniferous species in pure stands or in mixtures were established on abandoned agricultural land in northern Mississippi to determine which species or combination of species would most improve the physical and chemical properties of soil and litter. Five treatments were tested: pure plantings of eastern redcedar, loblolly pine, and shortleaf pine, and even mixtures of redcedar with shortleaf and redcedar with loblolly. Fifteen-year results indicated the planted pines, particularly loblolly, were clearly superior to redcedar for rehabilitation of the thin loessial soil. The pure pine treatments accumulated far more litter and increased water transmission rates far more than did the pure redcedar treatment. Litter accumulation beneath redcedar was insufficient to prevent soil erosion. Mixtures of pine and redcedar appeared to offer no advantages over pure stands of pine.

Table 3. CHANGES IN PHYSICAL PROPERTIES OF SOIL[1]

Plot	Year	Depth of A_1	Volume by weight	Pore space		Water trans-mission	Soil nitrogen	Organic matter	Exchange-able calcium	Total ex-change-able bases
				Large	Total					
		cm	*g/cc*	*% by vol*		*mm/hr*	*% by weight*		*meq/100 g*	
Redcedar	1951	2.97	1.15	17	56	133	0.11	2.7	2.7	4.3
	1966	3.66[2]	1.28	17	57	84	0.27	3.3	6.6	9.9
Shortleaf	1951	1.75	1.26	14	53	38	0.12	2.8	2.5	3.8
	1966	1.85	1.27	17	47	141	0.15	3.3	4.8	7.7
Loblolly	1951	2.26	1.38	19	48	85	0.06	1.9	1.5	2.2
	1966	2.49	1.36	22	40	187	0.15	2.2	4.2	6.5
Redcedar-shortleaf	1951	0.84	1.36	14	49	43	0.08	2.2	2.5	3.6
	1966	0.94	1.39	15	48	43	0.14	2.8	4.4	9.2
Redcedar-loblolly	1951	1.37	1.35	13	49	42	0.08	2.2	1.7	3.4
	1966	1.96	1.25	15	50	132	0.10	2.9	3.5	8.3

[1] Values are averages of 15 samples.
[2] Six of the 15 samples had fresh alluvium on top of the A1 horizon and were not used in this calculation.

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